GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

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| Subject name and code | Modern functional materials, PG_00068811 | | | | | | |
| Field of study | Biomedical Engineering, Biomedical Engineering, Biomedical Engineering | | | | | | |
| Date of commencement of studies | February 2027 | | Academic year of realisation of subject | 2027/2028 | | | |
| Education level | second-cycle studies | | Subject group | Optional subject group<br>Specialty subject group<br>Subject group related to scientific research in the field of study | | | |
| Mode of study | Full-time studies | | Mode of delivery | at the university | | | |
| Year of study | 2 | | Language of instruction | Polish | | | |
| Semester of study | 3 | | ECTS credits | 2.0 | | | |
| Learning profile | general academic profile | | Assessment form | assessment | | | |
| Conducting unit | Department of Chemistry and Technology of Functional Materials -> Faculty of Chemistry -> Faculties of Gdańsk University of Technology | | | | | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | | prof. dr hab. inż. Ewa Wagner-Wysiecka | | | | |
| | Teachers | | | | | | |
| Lesson types | Lesson type | Lecture | Tutorial | Laboratory | Project | Seminar | SUM |
| | Number of study hours | 15.0 | 0.0 | 15.0 | 0.0 | 0.0 | 30 |
| | E-learning hours included: 0.0 | | | | | | |
| Learning activity and number of study hours | Learning activity | Participation in didactic classes included in study plan | | Participation in consultation hours | Self-study | | SUM |
| | Number of study hours | 30 | | 3.0 | 17.0 | | 50 |
| Subject objectives | The aim of the course is to present the relationship between the properties of functional materials, their chemical structure and production methods leading to functional materials with different properties and application areas: energy storage and conversion devices, electronics, photonics, medicine. | | | | | | |

| Learning outcomes | Course outcome | Subject outcome | Method of verification |
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| | [K7_K01] is ready to create and develop models of proper behaviour in the work and life environment; undertake initiatives; critically evaluate actions of their own, teams and organisations they are part of; lead a group and take responsibility for its actions; responsibly perform professional roles taking into account changing social needs, including: - developing the achievements of the profession, - observing and developing rules of professional ethics and acting to comply to these rules | Student is aware of the responsibility of professional work, understands the importance of making decisions in accordance with ethical and social standards | [SK1] Assessment of group work skills |
| | [K7_W54] knows and understands in-depth selected aspects of biomedical engineering, in particular chemistry, biochemistry, biomaterials and materials science, as well as methods and theories explaining the complex relationships between them, constituting advanced general knowledge in the field of technical sciences | The student has advanced knowledge in the field of chemistry of functional materials, including their structure, properties and synthesis methods, and understands the complex relationships between chemical composition, structure, and applications in biomedical engineering. | [SW1] Assessment of factual knowledge |
| | [K7_U12] is able, to an increased extent, to analyze the operation of components and systems related to the field of study, as well as to measure their parameters and study their technical characteristics, and to plan and carry out experiments related to the field of study, including computer simulations, interpret the obtained results and draw conclusions | The student is able to plan and carry out experiments and analyse the parameters of functional materials using appropriate research techniques, and to interpret the obtained results taking into account their applications in technical and biomedical systems. | [SU3] Assessment of ability to use knowledge gained from the subject<br>[SU4] Assessment of ability to use methods and tools |
| | [K7_U08] while identifying and formulating engineering tasks specifications and solving these tasks, can: - apply analytical, simulation and experimental methods, - notice their systemic and non-technical aspects, - make a preliminary economic assessment of suggested solutions and engineering work | The student is able to identify an engineering problem in the field of functional material applications and propose a solution using analytical, experimental or simulation methods, taking into account system-level, non-technical aspects and a preliminary economic evaluation of the proposed solution. | [SU2] Assessment of ability to analyse information |

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| Subject contents | Course content – lecture<br>Electrode materials: synthesis, characterization and applications in energy storage devices for technical, medical, and biomedical engineering purposes.<br>Functional polymers: synthesis methods, properties, and their use in medicine, pharmacy, and in ultrafiltration and nanofiltration processes.<br>Materials with magnetic properties and optically active materials synthesis, characterization, and selected areas of application in technology, medicine, and biomedical engineering.<br><br>The project classes involve the development of a design solution for a biomedical device based on a selected group of functional materials. The laboratory classes aim to familiarise students with the synthesis methods of selected groups of functional materials and the methods of their characterization.<br><br>**Lecture**<br><br>1. Definition and types of functional materials<br>2. Metals (groups I, II, transition metals) - bulk phases, metal nanoparticles - a redox activity series in aqueous and non-aqueous electrolytes for bulk metals and nanometals.<br>3. Semiconductors from the group of transition metal chalcogenides - characteristics of the bulk phase and 2-D nanomaterials.<br>4. Carbon materials - natural graphite, synthetic graphite, carbon nanomaterials, doped diamond, biomass derived pyrolytic carbons, graphene-like g-$C_3N_4$.<br>5. Methods of producing electrode layers from functional materials. Types of substrate, types of binder<br>6. Application of electrodes in electrochemical devices for energy storage and conversion<br>7. Macromolecules as functional materials.<br>8. Biomedical polymers: synthesis and their application areas.<br>9. Formulation, development & manufacturing of drug delivery systems.<br>10. Shape-memory and self-organization of functional materials.<br>11. Application of macromolecules in ultra- and nanofiltration.<br>12. Materials based on classical dyes and pigments vs. plasmon nanomaterials<br>13. Multifunctional photochromic materials and photoswitches.<br>14. Materials with magnetic properties<br>15. Surface functionalized materials<br>16. Applications of selected optical active materials: sensors, actuators, fotovoltaic cells, optoelectronic devices<br>17. Bioinspired functional materials<br><br>**Project**<br><br>Design of device for biomedical applications based on a selected group of functional materials. Two presentations: 1. literature review and design assumptions 2. overview of the proposed design solution, discussion of the results<br><br>**Laboratories**<br><br>1. Preparation, characterization and applications of optical active materials - carbon dots<br><br>2. Gas sorption and detection with the use of organometallic porous materials MOFs<br><br>3. Synthesis and properties analysis of polymers for biomedical applications<br><br>4. Methods of obtaining and potential application of polymer membranes and nanomembranes<br><br>5. Synthesis and characterization of materials for dye solar cells |
| Prerequisites and co-requisites | Knowledge of chemistry, biochemistry, basic analytical methods. Ability to use basic laboratory equipment. |

Assessment methods and criteria

| Subject passing criteria | Passing threshold | Percentage of the final grade |
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| Lecture - written colloquium covering the issues discussed during the lecture | 51.0% | 40.0% |
| Laboratory -participation in all laboratory exercises and passing appropriate tests | 100.0% | 30.0% |
| Project - two presentations: 1. literature review and design assumptions 2. discussion of the proposed design solution, discussion of the results | 51.0% | 30.0% |

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| Recommended reading | Basic literature | 1. Recent Advances in Complex Functional Materials. From Design to Application, E. Longo, F. de Almeida La Porta (Eds.), Springer International Publishing AG 2017, ISBN 978-3-319-53898-3 (eBook), DOI 10.1007/978-3-319-53898-3<br>2. X. D. Liu, A. R. Esker, M. Häußler, Ch. Kim, P. Lucas, M. Matsunaga, N. Nishi, J.-J. Robin, B. Z. Tang, D. A. Wang, M. Yamada, H. Yu, Functional Materials and Biomaterials, Springer-Verlag Berlin Heidelberg 2007, DOI 10.1007/978-3-540-71509-2<br>3. Magnetism and Structure in Functional Materials, A. Planes, L. Mañosa, A. Saxena (Eds.), Springer-Verlag Berlin Heidelberg 2005, 978-3-540-31631-2 (eBook), DOI 10.1007/3-540-31631-0<br>4. R. D. Munje, S. Prasad, E. Graef, Functional Materials: For Sensing/Diagnostics, w: Handbook of Solid State Chemistry, R. Dronskowski, S. Kikkawa, A. Stein (Eds.), WileyVCH Verlag GmbH & Co. KGaA 2017, DOI: 10.1002/9783527691036<br>5. V. Sudarsan, Optical Materials: Fundamentals and Applications, w: Functional Materials. Preparation, Processing and Applications, str. 285-322, Elsevier Inc. 2012, DOI 10.1016/C2010-0-65659-8<br>6. Handbook of Smart Materials in Analytical Chemistry, M. de la Guardia, F. A. EsteveTurrillas (Eds.), John Wiley & Sons Ltd, 2019<br>7. S.O. Kasap, K. Koughia, Jai Singh, Harry E. Ruda, Asim K. Ray, Fundamental Optical Properties of Materials I, w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 1-36. DOI 10.1002/9781119506003.ch1<br>8. S.O. Kasap, K. Koughia, Jai Singh, Harry E. Ruda, Asim K. Ray, Fundamental Optical Properties of Materials II, w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 37-65. DOI 10.1002/9781119506003.ch2<br>9. J. M. Hvam, Optoelectronic Properties and Applications of Quantum Dots, w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 503-536. DOI 0.1002/9781119506003.ch17<br>10. M. A. J. Mazumder, H. Sheardown, A. Al-Ahmed, Functional Polymers, Springer, Cham 2019, ISBN 978-3-319-95987-0, DOI: 10.1007/978-3-319-95987-0<br>11. Instrukcje do ćwiczeń laboratoryjnych |
| | Supplementary literature | 1. M. Chen, X. Fu, Z. Chen, J. Liu, W. H. Zhong, Protein-Engineered Functional Materials for Bioelectronics, *Advanced Functional Materials*, 31, (2021), 2006744.DOI 10.1002/adfm.202006744<br>2. A. Edgar, Optical Properties of Glasses w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 83-128. DOI 0.1002/9781119506003.ch4<br>3. T. Aoki, Photoluminescence w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 157-202. DOI 10.1002/9781119506003.ch6<br>4. D. Xiao, L. Gu, Origin of functionality for functional materials at atomic scale, *NanoSelect*, 1, (2020) 183-199. DOI 10.1002/nano.202000020<br>5. A. Moores, F. Hajiali, T. Jin, G. Yang, M. Santos, E. Lam, Mechanochemical Transformations of Biomass into Functional Materials, *ChemSusChem*, w druku, (2022) DOI 10.1002/cssc.202102535<br>6. J. Kawamata, Y. Suzuki, M. Tominaga, From Adsorbed Dyes to Optical Materials, *Developments in Clay Science*, 9 (2018) 361-375. DOI 10.1016/B978-0-08-102432-4.00011-1<br>7. L.Y. Chu, R. Xie, X. J. Ju, W. Wang, Smart Hydrogel Functional Materials,Chemical Industry Press, Beijing and Springer Berlin Heidelberg 2013, ISBN 978-3-642-39538-3 (eBook), DOI 10.1007/978-3-642-39538-3<br>8. M. Jenkins, Biomedical polymers, Woodhead Publishing Series in Biomaterials 2007, ISBN-10:1845690702<br>9. T. A. Saleh, V. K. Gupta, Nanomaterial and Polymer Membranes: Synthesis, Characterization, and Applications, Elsevier 2016, ISBN: 0128047038<br>10. Cornelia Breitkopf; Karen Swider-Lyons, Springer Handbook on Electrochemical Energy, Springer 2016.<br>11. A. S. Aricò, P. Bruce, B. Scrosati, J. M. Tarascon, and W. Van Schalkwijk, Nanostructured materials for advanced energy conversion and storage devices, *Nature Materials*, vol. 4, no. 5, pp. 366377, 2005. |
| | eResources addresses | |
| Example issues/ example questions/ tasks being completed | j.w. | |
| Practical activites within the subject | Not applicable | |